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(54) TUBULAR MEMBER FOR TUNNEL EXCAVATION USE

(71) We, NISHIMATSU CONSTRUCTION COMPANY, LIMITED, a Japanese Body Corporate, of 13 Shiba Nishikubo Sakuragawa-cho, Minato-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a tubular member for use in the construction of tunnels in the ground underneath existing roads, railroads, rivers or buildings and the like.

The conventiinal methods of excavating a tunnel in the ground underneath existing roads, railroads, rivers or buildings and the like, include methods such as that of temporarily diverting the road, railroad or river to another location followed by tunneling or excavating from above the ground and thereafter filling in the earth, that of using timbering and performing the excavation while driving in sheet piles to form the tunnel walls, that of carrying out the excavation with a shield excavating machine, or the freezing method in which the moisture contained in the ground is artificially frozen. However, these conventional methods of construction have the drawback that their construction stretches over a long period of time, as well as other drawbacks such as hindrance of road and railroad traffic, obstruction of the flow of the rivers which may be hazardous to the excavation project, or causing subsidence of the ground. Another shortcoming is the construction cost. Further, another method of tunneling the ground underneath existing roads, railroads or buildings and the like, comprises repeatedly cutting horizontal bores and filling the bores with concrete or mortar thus constructing a tunnel wall, whereafter material is excavated from between the tunnel wall and floor. In this case also, there is, however, the drawback that there may be leakage of water from between concrete or mortar filled bores and also subsidence of the ground in those cases where the bores have not been adequately filled with the concrete or mortar.

Further, there is also known a method in which a continuous vertical wall is constructed by driving in vertically steel pipes having longitudinally disposed couplings along their outer surfaces. However, even though this method could be adapted to the construction of a horizontally disposed continuous wall by driving the foregoing pipes in the horizontal direction, a perfect continuous wall cannot be expected, because of the deviation of the pipes even though the pipes are driven in horizontally, such as the front end of the pipe declining due to the weight of the pipe, the pipe swerving out of its course due to the force applied in driving it in, the pipe deviating from its course due to the rotation of the drill or oversize bores when the pipes are inserted in oversize bores.

As a method for improving on the foregoing deficiencies of the conventional methods, in our copending Application No. 46900/72 (Serial No. 1,403,033), there is proposed a method of constructing a tunnel below roads, railroads, riverbeds or buildings, said method comprising driving into the ground below the road, railroad, riverbed or building a plurality of pipes, each of which has disposed longitudinally on the outside surface thereof coupling means, said pipes being driven in horizontally or at an angle close to horizontal in such a manner that the pipes are coupled to each other to prevent separation radially of the pipes by means of the coupling means to form a wall having a configuration approximating the profile of the tunnel that is to be excavated, and thereafter excavating the tunnel using said wall as a lining.

The object of the present invention is to provide a tubular member, which is suitable for constructing the hereinabove-described pipe wall in the foregoing method.

According to the present invention, there is provided a tubular member for constructing the wall of a tunnel, said tubular member comprising a pipe on whose outer surface are disposed longitudinally thereof, at one circumferential location, a male coupling portion, and, at another circumferential location, a female coupling portion, the male

[*Price 33p*]

coupling portion comprising a cylindrical section and the female coupling portion comprising an annular section having a longitudinally extending slot, the outer diameter of the cylindrical section of the male coupling portion being smaller than the inner diameter of the female coupling portion but greater than the width of the said slot whereby a pair of the tubular members can be connected side by side with the male coupling portion of one being received within the female coupling portion of the other.

The present invention will be more fully understood from the following description taken with the accompanying drawings, wherein:

Figure 1 is a cross-sectional view of a tubular member according to the present invention;

Figure 2 is a perspective view of the tubular member of Figure 1;

Figure 3 is a cross-sectional view illustrating the coupling of two tubular members;

Figure 4 is a sectional view illustrating the state of arrangement of a plurality of the tubular members in arch fashion along the profile of a tunnel that is to be excavated in the ground below an existing railroad;

Figure 5 is a sectional view taken along line V—V of Figure 4;

Figure 6 is a sectional view illustrating the state where a tunnel has been excavated using the steel pipe wall shown in Figure 4 as the tunnel lining; and

Figures 7—9 are cross-sectional views showing the conventional methods of coupling steel pipes which are driven into the ground vertically.

In a most preferred embodiment of the present invention, the tubular member comprises a main steel pipe or body 1 having disposed longitudinally ahereof a first male coupling means 2, and having disposed likewise longitudinally of the main body 1 substantially diametrically opposite said first coupling means 2 a second female coupling means 3 of annular section and having a longitudinally extending slot 31. The first coupling means 2 can be made, for example, by welding a steel pipe 21 of small diameter to the main tubular body 1 through the intermediary of a steel web 22. The second coupling means 3 is formed by welding to the main tubular body 1 a steel pipe having an inside diameter greater than the outside diameter of the aforesaid steel pipe 21 and providing in said second coupling means along its entire length the slot 31 facing radially outwardly of the main tubular body 1; the opening provided by the slot is of a dimension smaller than the outside diameter of the steel pipe 21 but greater than the thickness of the steel web 22.

Hence, when, as shown in Figure 3, the first coupling means 2 of the tubular member A is inserted into the second coupling means 3 of another tubular member B in such a manner that the steel pipe 21 is enclosed by the slotted ring-shaped coupling means 3 and the steel web 22 portion is clasped in the slot 31, the first tubular member A and the second tubular member B become coupled so that they cannot be separated by a force exerted on them and tending to separate them in the radial direction.

Now, a method of excavating a tunnel under an existing railroad using the tubular member of the present invention will be described below.

As shown in Figures 4 and 5, the first step consists of excavating a vertical shaft 5 at one or both sides of and near the existing railroad 4. The tubular members 1 of the present invention are then driven from the side wall of said vertical shaft 5 horizontally, or at an angle close to horizontal, at prescribed intervals, using a ram or a rotary excavator, while coupling the tubular members against separation radially of the members by means of the coupling means 2 and 3, the operation being so performed that said tubular members 1 are disposed along the profile of the section 6 to be excavated and hence become as a whole an arch-like arrangement suitable for use as the tunnel lining for the excavation of the tunnel. Next, as the second step, the steel pipe wall 7, constructed as above described, is used as a tunnel lining and the excavation of a tunnel 6^1 in the ground underneath the railroad 4 is carried out as shown in Figure 6. Needless to say, additional steel supports can be used conjointly if desired. Further, the steel pipe wall 7 can be made watertight by packing the vicinity of the coupling means of the several tubular means with mortar or introducing grout hereto, utilizing the steel pipes 21 of the couplings 2.

In addition to the case described in which the operation is carried out from the side wall of a vertical shaft 5 excavated close to the existing railroad (likewise applicable to the case of a road, river or building and the like), the tubular members can also be used in the case where the operation is to be carried out from the facing of a tunnel, whose excavation has progressed up to a point near an existing road, railroad, river or building and the like, or in the case where the operation is to be carried out from the side of the roadbed of an existing road or railroad whose roadbed is high. While the drawing illustrates the instance of the construction of a wall of steel pipes having the form of an arch, it goes without saying that there are instances where the steel pipe wall is constructed in a circular or polygonal form depending upon the character of ground

or the configuration of the tunnel to be excavated. In such cases, rather than having the coupling means 2 and 3 disposed on the main tubular body 1 at positions diametrically opposite each other, as shown in Figure 1, it will be more convenient for these coupling means to be located deviatingly from the diametrically opposite positions. Heretofore, couplings such as shown in Figures 7—9 are known in the case of the steel pipe piles that are driven into the ground vertically. However, when steel pipes having couplings such as these are to be used for tunnel linings, various difficulties are experienced. That is to say, in the case of the coupling shown in Figure 7, it readily separates and, in addition, although this coupling can permit movement of the pipes in the upwards and downwards directions as reviewed in Figure 7, transverse relative movement of the pipes causes the connection to become disengaged. Hence, the construction of a steel pipe wall of a prescribed configuration is difficult. In the case of the coupling shown in Figure 8, the allowable angle of rotation of the coupling is small, and moreover this coupling includes a T-shaped section susceptible to deformation. The coupling shown in Figure 9 separates very easily and is also susceptible to leakage of water. The coupling means of the tubular member according to the invention on the other hand is not prone to these disadvantages, its allowable angle of rotation being great, as well as not being easily separated and not susceptible to breakage or deformation. Hence, when tubular members according to the invention are used in carrying out the tunneling operation, irregularity of the direction in which the members are driven does not occur, and the leakage of water may be reduced.

Further, when tubular members according to the invention are used in carrying out the tunneling project, there is less possibility of a decline in the yield strength of the ground and subsidence of the ground. Hence, a wall of interconnected steel pipes, which is not only strong but, if necessary, also watertight, can be constructed with good precision in the ground below existing roads, railroads, rivers or buildings and the like without hindering the traffic of said roads or railroads or the flow of the rivers at all, or with no damage to the buildings and the like. As a result, the work of the tunnel excavation can be carried out safely and rapidly as well as at low cost. Further, since a steel pipe wall formed of tubular members according to the invention can be utilized as such as either the principal or auxiliary lining of the tunnel, the cost of the tunneling project can be reduced.

WHAT WE CLAIM IS:—

1. A tubular member for constructing the wall of a tunnel, said tubular member comprising a pipe on whose outer surface are disposed longitudinally thereof, at one circumferential location, a male coupling portion, and, at another circumferential location, a female coupling portion, the male coupling portion comprising a cylindrical section and the female coupling portion comprising an annular section having a longitudinally extending slot, the outer diameter of the cylindrical section of the male coupling portion being smaller than the inner diameter of the female coupling portion but greater than the width of the said slot whereby a pair of the tubular members can be connected side by side with the male coupling portion of one being received within the female coupling portion of the other.

2. A tubular member according to Claim 1, wherein the male and female coupling portions are disposed on diametrically opposite sides of said pipe.

3. A tubular member according to Claim 1, wherein the male and female coupling portions are disposed on said pipe at positions which deviate from being diametrically opposed.

4. A tubular member according to Claim 1, 2 or 3 wherein the cylindrical section of the male coupling portion is connected to the pipe by a web extending radiall outwardly from the pipe.

5. A tubular member according to any one of the preceding Claims wherein the pipe is of steel.

6. A tubular member substantially as hereinbefore described with reference to and as shown by Figures 1 to 6 of the accompanying drawings.

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5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

Fig. 3

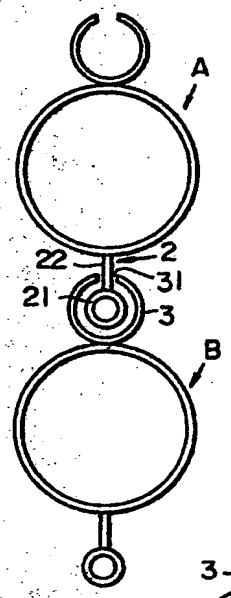


Fig. 1

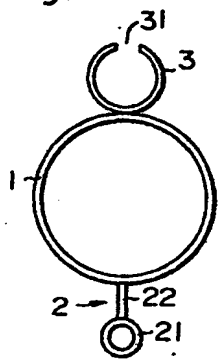


Fig. 2

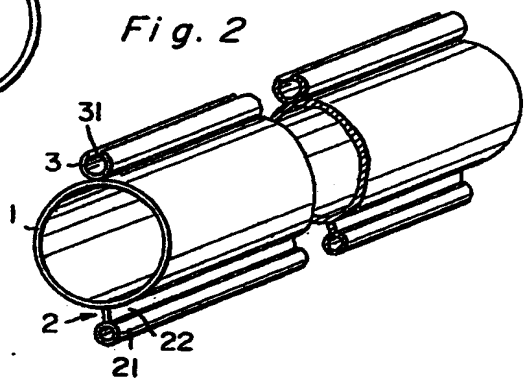
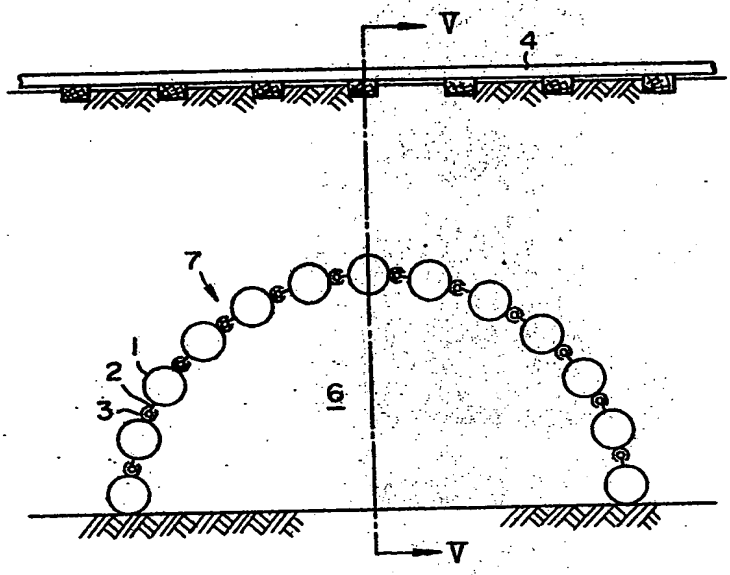


Fig. 4



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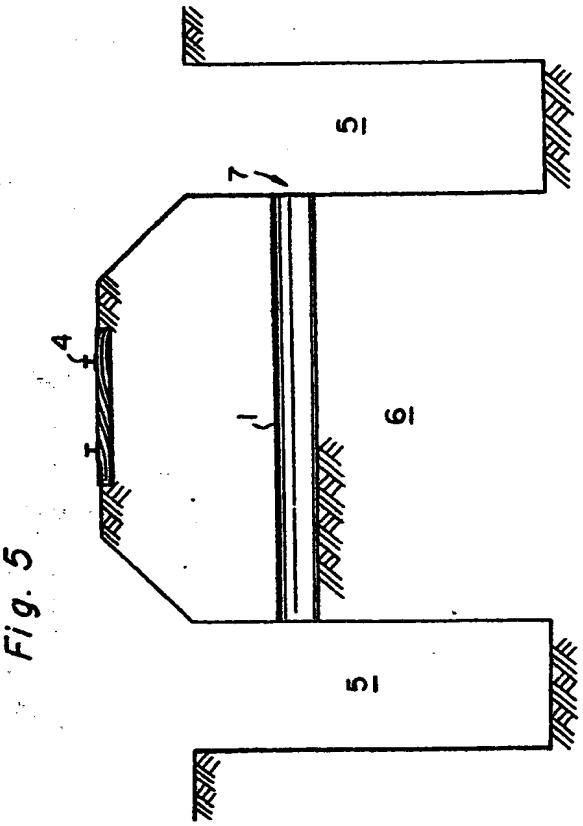

Fig. 5

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Fig. 6

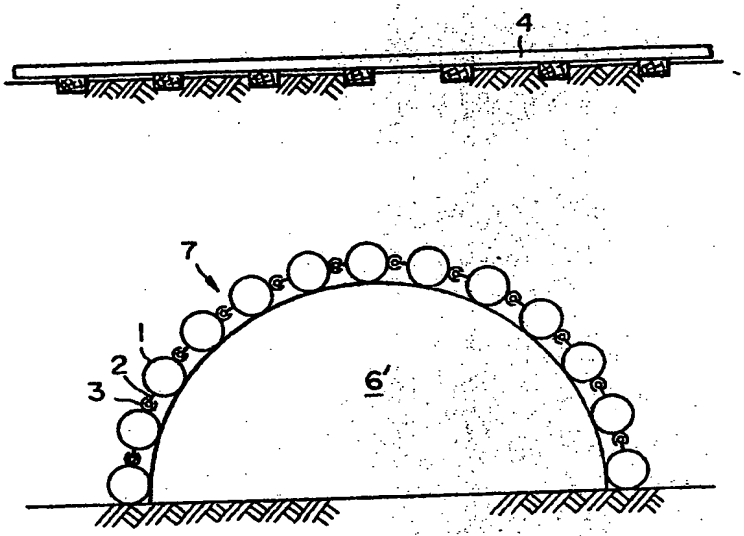


Fig. 7

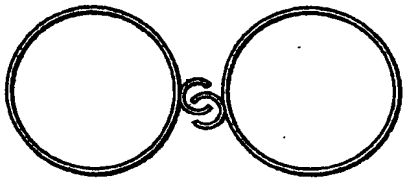


Fig. 8

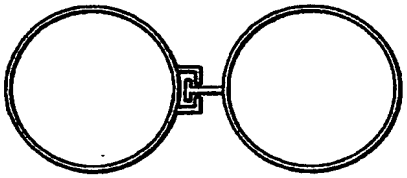
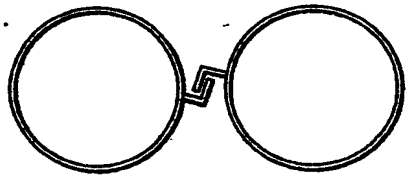


Fig. 9



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